

(12) **United States Patent**  
**Dionne et al.**

(10) **Patent No.:** **US 10,527,012 B2**  
(45) **Date of Patent:** **Jan. 7, 2020**

(54) **ENGINE ASSEMBLY WITH ENGINE AND COOLER COMPARTMENTS**

(71) Applicant: **PRATT & WHITNEY CANADA CORP.**, Longueuil (CA)

(72) Inventors: **Luc Dionne**, Candiac (CA); **Bruno Villeneuve**, Boucherville (CA); **Andre Julien**, Ste-Julie (CA); **Serge Dussault**, Ste-Julie (CA)

(73) Assignee: **Pratt & Whitney Canada Corp.**, Longueuil, Quebec (CA)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 184 days.

(21) Appl. No.: **15/666,773**

(22) Filed: **Aug. 2, 2017**

(65) **Prior Publication Data**

US 2019/0003430 A1 Jan. 3, 2019

**Related U.S. Application Data**

(60) Provisional application No. 62/526,541, filed on Jun. 29, 2017.

(51) **Int. Cl.**

**F02M 35/10** (2006.01)  
**F01P 3/20** (2006.01)  
**F01P 7/14** (2006.01)  
**F02B 37/00** (2006.01)  
**F02B 33/38** (2006.01)

(52) **U.S. Cl.**

CPC ..... **F02M 35/10268** (2013.01); **F01P 3/20** (2013.01); **F01P 7/14** (2013.01); **F02M 35/10157** (2013.01); **F02B 33/38** (2013.01); **F02B 37/00** (2013.01); **F02M 35/10203** (2013.01)

(58) **Field of Classification Search**

CPC ..... B60K 11/06; B60K 11/00; B60K 11/08; B60R 16/04

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,059,080 A 11/1977 Rudert  
4,590,889 A 5/1986 Hiereth  
4,815,282 A \* 3/1989 Wilkinson ..... F02B 37/001  
60/247

(Continued)

FOREIGN PATENT DOCUMENTS

DE 102015008060 A1 10/2015  
DE 102015008060 A1 \* 12/2015 ..... F01P 11/10  
EP 2602143 A1 6/2013

OTHER PUBLICATIONS

English Translation DE 102015008060 A1 English Translation (Year: 2015).\*

(Continued)

*Primary Examiner* — Mark A Laurenzi

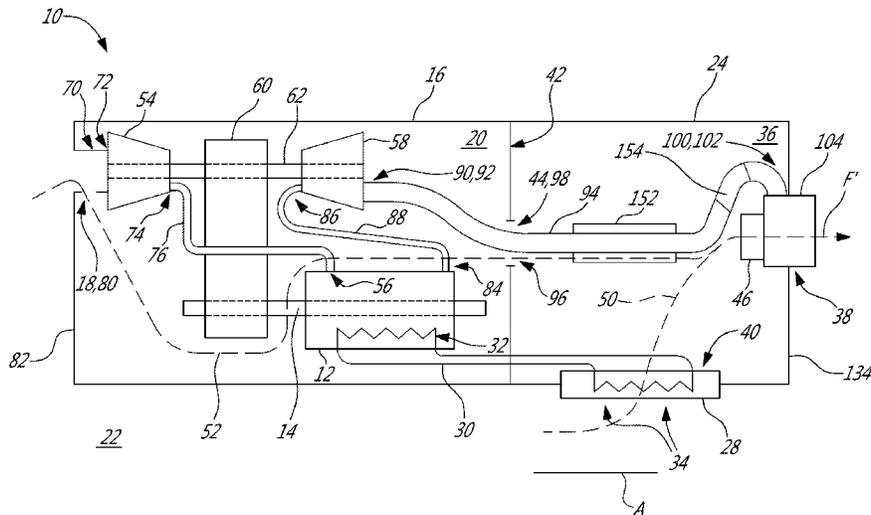
*Assistant Examiner* — Shafiq Mian

(74) *Attorney, Agent, or Firm* — Norton Rose Fulbright Canada L.L.P.

(57) **ABSTRACT**

An engine assembly includes an engine compartment containing an internal combustion engine and a cooler compartment adjacent the engine compartment containing a heat exchanger. The engine and cooler compartments have an opening defined therebetween. A forced air system is operable to drive an airflow. A method for cooling the engine and its compartment is disclosed.

**22 Claims, 5 Drawing Sheets**



(56)

**References Cited**

U.S. PATENT DOCUMENTS

5,351,476 A 10/1994 Laborie et al.  
 5,778,658 A \* 7/1998 Lamando, Jr. .... F02K 1/822  
 6,282,881 B1 \* 9/2001 Beutin ..... B64D 33/10  
 7,654,087 B2 \* 2/2010 Ulliyott ..... F01D 25/12  
 7,753,036 B2 7/2010 Lents et al.  
 7,775,044 B2 \* 8/2010 Julien ..... F02C 3/055  
 7,861,512 B2 \* 1/2011 Olver ..... F02C 7/14  
 9,027,345 B2 \* 5/2015 Julien ..... F01C 1/22  
 9,416,730 B2 8/2016 Skilton  
 9,435,261 B2 9/2016 DeVita et al.  
 9,896,998 B2 \* 2/2018 Thomassin ..... F01C 1/22  
 9,932,892 B2 \* 4/2018 Thomassin ..... F02B 29/0418

9,994,332 B2 \* 6/2018 Ulliyott ..... F02C 3/10  
 2008/0006739 A1 1/2008 Mochida et al.  
 2011/0284298 A1 11/2011 Ajisaka  
 2013/0133963 A1 \* 5/2013 Ajisaka ..... B60K 11/04  
 2013/0240284 A1 9/2013 Ajisaka  
 2015/0275749 A1 10/2015 Thomassin et al.  
 2015/0275756 A1 \* 10/2015 Bolduc ..... F01C 11/002  
 2016/0236767 A1 8/2016 Mores et al.  
 2017/0037756 A1 \* 2/2017 Julien ..... B64D 27/10

OTHER PUBLICATIONS

European Search Report received in counterpart Application No. EP 18181024.  
 TEOS Powertrain Engineering, Jet A-1 aircraft engine, www.teos-engineering/experience/jet-a1-aircraft-engine/, May 4, 2017.

\* cited by examiner



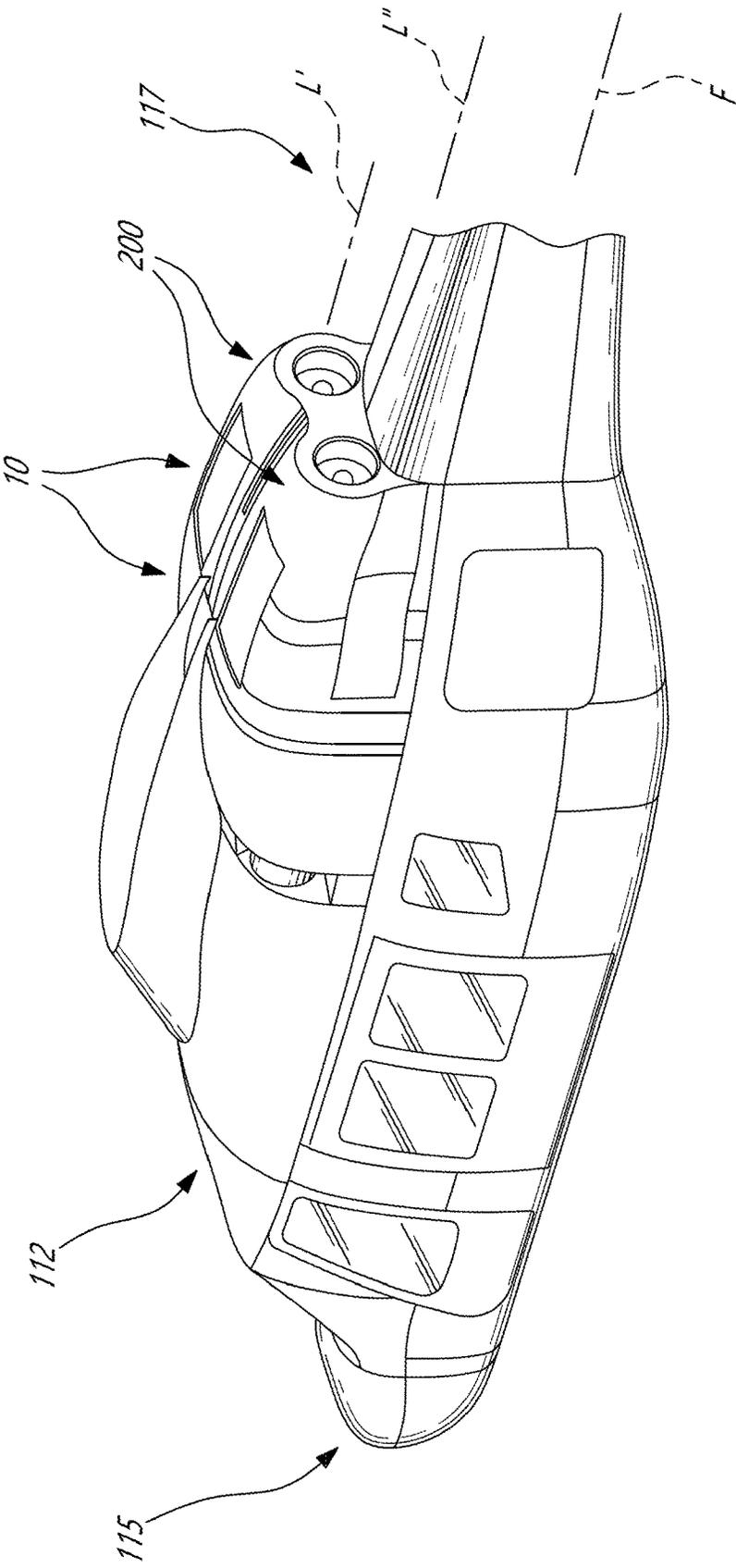


Fig-2

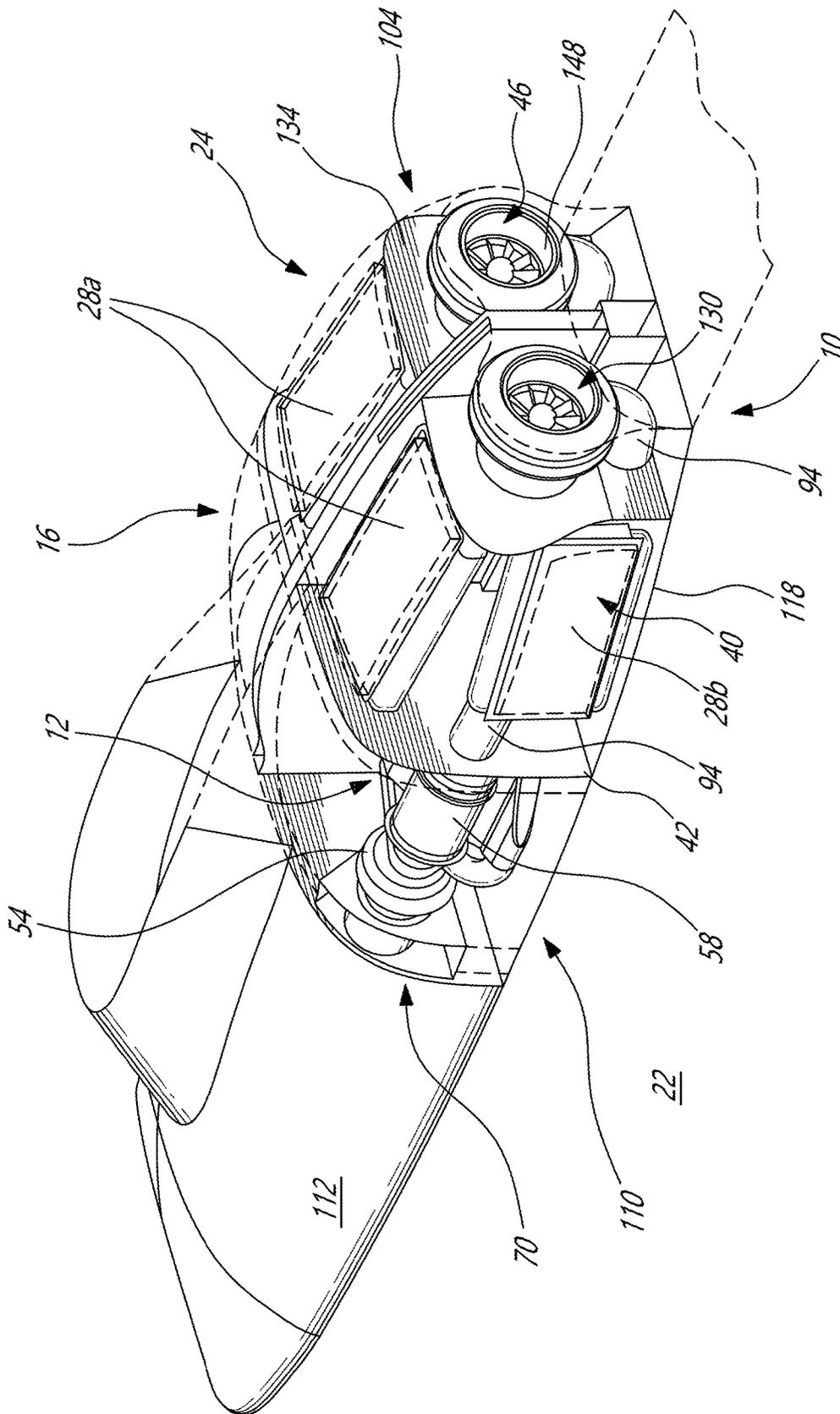
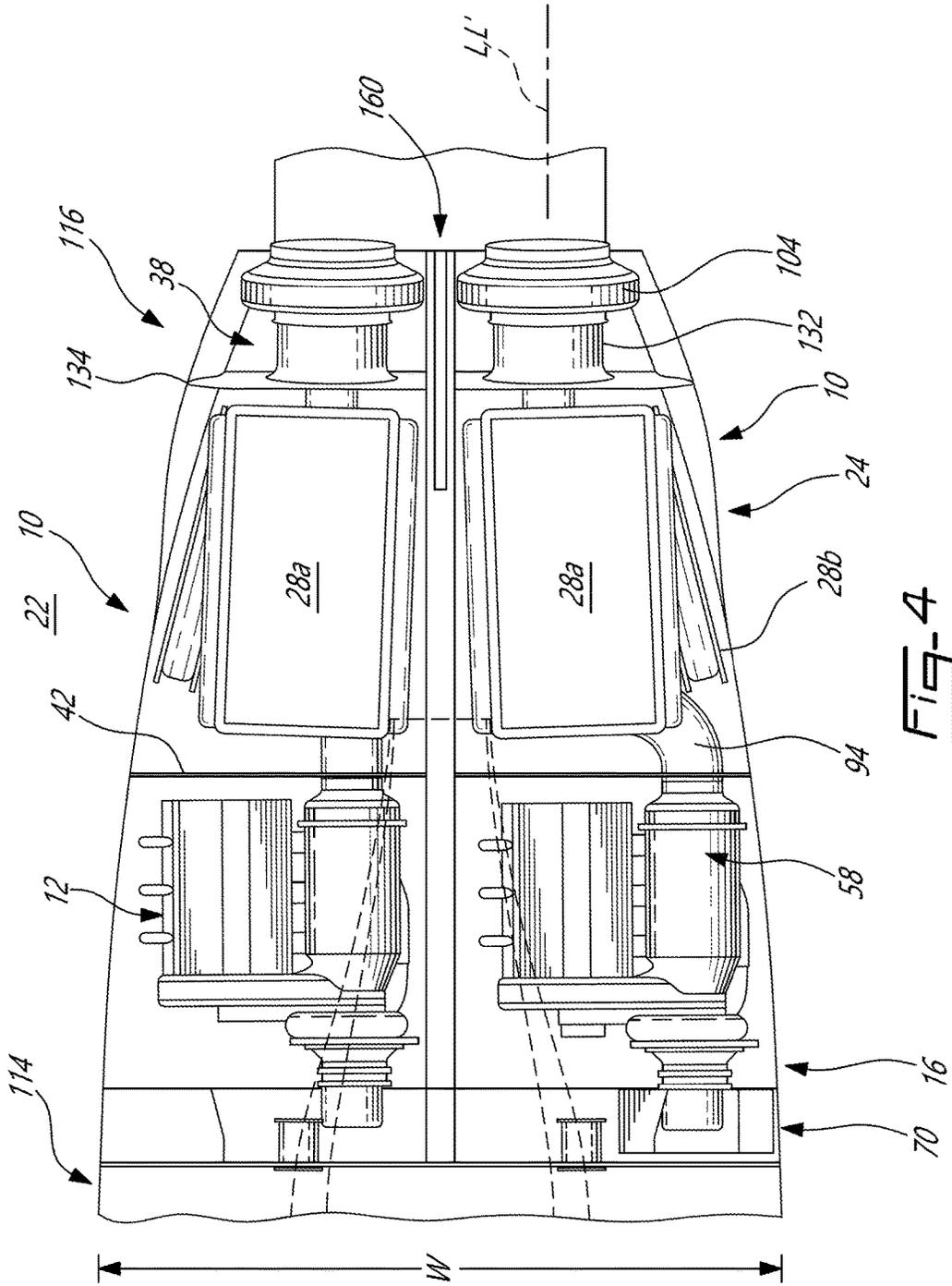


FIG-3





## ENGINE ASSEMBLY WITH ENGINE AND COOLER COMPARTMENTS

### CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority from U.S. provisional application No. 62/526,541 filed Jun. 29, 2017, the entire contents of which are incorporated by reference herein.

### TECHNICAL FIELD

The application relates generally to engine assemblies with internal combustion engines and, more particularly, to systems and methods used to cool such engines.

### BACKGROUND OF THE ART

In some aircraft, for example helicopters, space may be limited for the installation of one or more engine(s). Liquid-cooled internal combustion engines typically require a cooler to cool the liquid coolant of the engine(s), as well as a blower or other forced air system to drive a cooling airflow through the cooler. In some instances, available space in the vehicle is limited, which may prevent the engine and cooler from being received in a common compartment. This may increase the cooling requirements for the engine, and thus require a further increase in the size of the cooler.

### SUMMARY

In one aspect, there is provided an engine assembly, comprising: an engine compartment containing an internal combustion engine, the internal combustion engine having internal cooling circuitry for fluid cooling of the engine, the engine compartment having an air intake fluidly connecting an interior of the engine compartment to an environment of the engine assembly; a cooler compartment separate from and adjacent the engine compartment, the cooler compartment containing a heat exchanger fluidly connected to the cooling circuitry of the internal combustion engine, an interior of the cooler compartment fluidly connected to the environment via an inlet and an outlet; a metered opening fluidly connecting the engine compartment to the cooler compartment; and a forced air system fluidly between the inlet and the outlet and operable to drive an airflow from the inlet to the outlet through the heat exchanger, and from the intake to the outlet through the metered opening.

In another aspect, there is provided an engine assembly comprising: a compartment having separate engine and cooler sections fluidly connected with each other through an opening, the engine section having an air intake fluidly connecting an interior of the engine section to an environment of the engine assembly, an interior of the cooler section fluidly connected to the environment of the engine assembly via an inlet and an outlet; a compound engine received in the engine section and including a compressor in fluid communication with the environment of the engine assembly, an internal combustion engine having an inlet in fluid communication with an outlet of the compressor, and a turbine having an inlet in fluid communication with an exhaust of the internal combustion engine, the turbine compounded with the internal combustion engine, the compressor in driving engagement with at least one of the turbine and the internal combustion engine; a heat exchanger received in the cooler section, the heat exchanger fluidly connected to a fluid circuitry of the compound engine, the interior of the

cooler section fluidly connected to the inlet of the cooler section via the heat exchanger; and a forced air system operable to drive an airflow, the forced air system in simultaneous fluid communication with a main flow path and a secondary flow path, the main flow path extending from the inlet of the cooler section to the outlet of the cooler section via the heat exchanger and the interior of the cooler section, the secondary flow path extending from the air intake of the engine section to the outlet of the cooler section via the interior of the engine section, the opening and the interior of the cooler section.

In another aspect, there is provided a method for cooling an internal combustion engine received in an engine compartment separated from a cooler compartment, the method comprising: expelling air from the cooler compartment to an environment with a forced air system to simultaneously create main and secondary airflows, wherein: creating the main airflow includes drawing outside air in the cooler compartment from the environment separately from the engine compartment; and creating the secondary airflow includes drawing additional air in the cooler compartment from the engine compartment through an opening fluidly connecting the cooler and engine compartments.

In a further aspect, there is provided an engine assembly within an aircraft vehicle, the vehicle having a longitudinal axis defined generally from a front end to a rear end, the engine assembly comprising: an engine compartment and a cooler compartment serially disposed in a direction of the longitudinal axis of the vehicle, the engine and cooler compartments separated from one another; an internal combustion engine disposed within the engine compartment; a heat exchanger disposed within the cooler compartment; a forced air system in the cooler compartment operable to drive an airflow through the heat exchanger.

### DESCRIPTION OF THE DRAWINGS

Reference is now made to the accompanying figures in which:

FIG. 1 is a schematic view of an engine assembly in accordance with a particular embodiment;

FIG. 2 is a schematic view of a vehicle containing two engine assemblies such as shown in FIG. 1, in accordance with a particular embodiment;

FIG. 3 is a schematic tridimensional view of an implementation of the engine assembly of FIG. 1 in the vehicle of FIG. 2, in accordance with a particular embodiment;

FIG. 4 is a schematic partially transparent top view of the implementation of FIG. 3; and

FIG. 5 is a schematic partially transparent side view of the implementation of FIG. 3.

### DETAILED DESCRIPTION

Referring to FIG. 1, an engine assembly 10 is generally shown and includes an internal combustion engine 12. In a particular embodiment, the internal combustion engine 12 comprises one or more rotary units each configured for example as a Wankel engine, or one or more reciprocating pistons. The internal combustion engine 12 drives a shaft 14 that is used for driving a rotatable load (not shown). It is understood that the engine assembly 10 may alternately be configured to drive any other appropriate type of load, including, but not limited to, one or more generator(s), propeller(s), accessory(ies), rotor mast(s), compressor(s), or any other appropriate type of load or combination thereof. In a particular embodiment, the internal combustion engine 12

is a rotary engine comprising three rotary units each configured as a Wankel engine, with a rotor cavity having a profile defining two lobes, preferably an epitrochoid, in which a rotor is received with the geometrical axis of the rotor being offset from and parallel to the axis of the rotor cavity, and with the rotor having three circumferentially-spaced apex portions and a generally triangular profile with outwardly arched sides, so as to define three rotating combustion chambers with variable volume.

In a particular embodiment, the engine assembly **10** is a compound cycle engine system or compound cycle engine such as described in Lents et al.'s U.S. Pat. No. 7,753,036 issued Jul. 13, 2010 or as described in Julien et al.'s U.S. Pat. No. 7,775,044 issued Aug. 17, 2010, or as described in Thomassin et al.'s U.S. patent publication No. 2015/0275749 published Oct. 1, 2015, or as described in Bolduc et al.'s U.S. patent publication No. 2015/0275756 published Oct. 1, 2015, the entire contents of all of which are incorporated by reference herein. The engine assembly **10** may be used as a prime mover engine, such as on an aircraft or other vehicle, or in any other suitable application.

The engine assembly **10** comprises an engine compartment **16** containing the internal combustion engine **12**. The engine compartment **16** has an air intake **18** fluidly connecting an interior **20** of the engine compartment **16** to an environment **22** of the engine assembly **10**. The engine assembly **10** further has a cooler compartment **24** adjacent the engine compartment **16**. In the illustrated embodiment, the engine compartment **16** and the cooler compartment **24** are serially disposed in a direction A parallel to the shaft **14** of the internal combustion engine **12**.

In the embodiment shown, the engine assembly **10** further includes a compressor **54** for compressing the air before it is fed to an air inlet **56** of the internal combustion engine **12**, and a turbine section **58** receiving the exhaust gases from the internal combustion engine **12**. It is understood that variations are possible, and that, for example, the compressor **54** and/or turbine section **58** may be omitted.

In the illustrated embodiment, the internal combustion engine **12**, the compressor **54**, and the turbine section **58** are in driving engagement with a gearbox **60**. The gear box **60** is configured to allow the turbine section **58** to compound power with the engine shaft **14** and to allow the turbine section **58** and/or the internal combustion engine **12** to drive the compressor **54**.

In the illustrated embodiment, the compressor **54** and the turbine section **58** are in a driving engagement with the gearbox **60**. In the illustrated embodiment, the compressor and turbine rotors are engaged to a same turbine shaft **62** which is drivingly engaged to the engine shaft **14** through the gearbox **60**; the turbine shaft **62** and the engine shaft **14** are parallel and radially offset from one another. Alternate configurations are possible, including, but not limited to, the rotor(s) of the compressor **54** being engaged to a shaft separate from the turbine shaft **62** (whether coaxial with the turbine shaft **62**, with the engine shaft **14**, or offset from both) and in driving engagement with the turbine shaft **62** and/or the engine shaft **14**, for example through the gearbox; and/or two or more of the shafts **62**, **16** extending at an angle (perpendicularly or otherwise) to each other.

In the depicted embodiment, the engine assembly **10** further comprises an intake plenum **70** fluidly connected to an inlet **72** of the compressor **54** and to the environment **22**, while an outlet **74** of the compressor **54** is in fluid communication with the air inlet **56** of the internal combustion engine **12**, for example through a conduit **76**.

The air intake **18** of the engine compartment is defined by an aperture **80** through the intake plenum **70**. The aperture **80** fluidly connects the environment **22** with the engine compartment **16** via the intake plenum **70**. In a particular embodiment, the air intake **18** of the engine compartment **16** is defined through a peripheral wall **82** of the engine compartment **16**. Other locations of the air intake **18** of the engine compartment **16** are contemplated.

The internal combustion engine **12** provides an exhaust flow of high pressure hot gas exiting at high peak velocity, in the form of exhaust pulses. In the illustrated embodiment, an exhaust **84** of the internal combustion engine **12** (corresponding to or communicating with an exhaust port of a respective rotary engines/reciprocating pistons of the internal combustion engine **12**) is in fluid communication with an inlet **86** of the turbine section **58** via a conduit **88**. Accordingly, the exhaust flow from the internal combustion engine **12** is supplied to the turbine section **58**. The turbine section **58** may comprise a single turbine, or two or more turbine stages in serial fluid communication; the two or more turbine stages may have different reaction ratios from one another. Other configurations are contemplated.

In the illustrated embodiment, an outlet **90** of the turbine section **58** is fluidly connected to an inlet **92** of an exhaust duct **94** for expelling combustion gases generated by the internal combustion engine **12** to the environment **22**. In a particular embodiment, an insulation layer **152** is disposed around the exhaust duct **94**. In a particular embodiment, the exhaust duct **94** includes a muffler **154** for decreasing noise generated by the engine and for treating the exhaust gases if required.

Still referring to FIG. 1, the cooler compartment **24** contains at least one heat exchanger **28**. The heat exchanger **28** has one or more first conduit(s) **30** (one in the embodiment shown) fluidly connected to a fluid circuitry **32** of the engine assembly **10**. In the embodiment shown, the fluid circuitry **32** is a cooling circuitry of the internal combustion engine **12** (e.g., coolant passages defined through the housing of the internal combustion engine **12**) and one or more second conduit(s) **34** (a plurality in the embodiment shown) in heat exchange relationship with the first conduit **30**; alternately, the fluid circuitry may include passages circulating coolant and/or lubricant to any suitable component of the engine assembly **10**. An interior **36** of the cooler compartment **24** is fluidly connected to the environment **22** via the second conduits **34** of the heat exchanger **28** and via an outlet **38** spaced apart from the heat exchanger **28**. The second conduits **34** of the heat exchanger **28** extend through, and define, an inlet **40** of the cooler compartment **24**.

The engine assembly **10** further includes a wall **42**, which may be a firewall, and which separates the engine compartment **16** from the cooler compartment **24**. Stated otherwise, in the embodiment shown, the engine and cooler compartments **16** and **24** share a common wall **42**. Alternately, one or more additional wall(s) could be provided between the engine compartment **16** and the cooler compartment **24**.

The engine compartment **16** and the cooler compartment **24** are thus disposed on opposite sides of the wall **42**. In the embodiment shown, the wall **42** is perpendicular to the axis A. The wall **42** has a metered opening **44** defined through the wall **42**. The metered opening **44** fluidly connects the engine compartment **16** to the cooler compartment **24**. Any other suitable feature to allow fluid communication between the engine compartment **16** and the cooler compartment **24** may be used.

The engine assembly **10** has a forced air system **46** adjacent the cooler compartment outlet **38** and operable to

drive an airflow  $F'$ . The forced air system **46** is in simultaneous fluid communication with a main flow path **50** and a secondary flow path **52**. The main flow path **50** extends through the second conduit **34** of the heat exchanger **28** to the outlet **38** of the cooler compartment **24** via the interior **36** of the cooler compartment **24**. The secondary flow path **52** extends from the air intake **18** of the engine compartment **16** to the outlet **38** of the cooler compartment **24** via the interior **20** of the engine compartment **16**, the metered opening **44** in the wall **42** and the interior **36** of the cooler compartment **24**. The flow paths **50**, **52** converge in the forced air system **46**. The source of air of both flow paths **50**, **52** is the environment **22** of the engine assembly **10**.

The forced air system **46** is configured to draw air out of the cooler compartment **24** toward the environment thereof **22**. The forced air system **46**, by drawing air out of the cooler compartment **24**, draws air from the environment **22** in the cooler compartment **24** through the second conduit **34** of the heat exchanger **28** and draws air from the environment **22** in the engine compartment **16** through the air intake **18**. The air that is drawn in the engine compartment **16** from the environment **22** passes from the engine compartment **16** to the cooler compartment **24** through the wall **42** via the metered opening **44**. To draw air in the cooler compartment **24**, the forced air system **46** creates a pressure drop in the cooler compartment **24** such that an air pressure in the cooler compartment **24** is less than an air pressure of the engine compartment **16** and of the environment **22**. Air is therefore drawn in the cooler compartment **24** to compensate for this pressure drop.

In the illustrated embodiment, the exhaust duct **94** passes through an aperture **96** extending through the wall **42** separating the engine compartment **16** from the cooler compartment **24**. In the illustrated embodiment, the metered opening **44** corresponds to a gap **98**, which may be an annular gap, between the exhaust duct **94** and a peripheral surface of the aperture **96**. The gap **98** is created by the difference between the diameter of the aperture **44** and the outer diameter of the exhaust duct **94**. Alternately, the metered opening **44** may include one or more aperture(s) in the wall **42** spaced apart from the aperture **96** that receives the exhaust duct **94**, or may be defined by one or more aperture(s) through which another structure extends, or which are completely free; for example, the exhaust duct **94** may extend elsewhere than through the wall **42**. In the illustrated embodiment, the aperture **96** is configured to be able to provide a flow in a range of from 2% to 10% of the gas turbine engine core flow, for example, 5% of the gas turbine engine core flow.

In the depicted embodiment, the exhaust duct **94** has an outlet **100** fluidly connected to an inlet **102** of an exhaust plenum **104**. The exhaust plenum **104** is configured for distributing the exhaust gases around the airflow  $F'$  generated by the forced air system **46**, for mixing the exhaust gases with this airflow  $F'$ . An example of this configuration is described in more detail herein below.

Now referring to FIG. 2, a helicopter **112** comprises two side-by-side engine assemblies **10** separated by a wall **160** (FIG. 4). Only one of the engine assemblies **10** of the helicopter **112** is described herein below; the other assembly **10** is identical or a mirror image of the described assembly, and accordingly will not be described separately herein. The helicopter **112** has a longitudinal axis  $F$  (e.g., roll axis) extending from front end **115** to a rear end **117** of the helicopter **112**, and the two engine assemblies **10** are offset along a direction perpendicular to the axis  $F$ . The two engine assemblies **10** may be coupled to a transmission (not shown)

of the helicopter **112** to drive a common load. In a particular embodiment, a power of the twin engine assemblies **10** is from 500 to 2000 horse power. A vehicle may comprise more than two engine assemblies **10**.

FIGS. 3-5 illustrate an exemplary configuration for the engine assembly **10** of FIGS. 1-2; other configurations are contemplated. In the embodiment shown, the engine and cooler compartments **16** and **24** are defined in an engine bay **110** of a vehicle **112**. Hence, the engine bay **110** has an engine section **16** and a cooler section **24** separated from the engine section **16** by the wall **42**. In a particular embodiment, the engine and cooler compartments, or sections, **16** and **24** are defined in a nacelle, and serially disposed in a direction of the longitudinal axis  $F$ . The wall **42** extends transversely, for example perpendicularly, to the longitudinal axis  $F$ . In the depicted embodiment, the engine and cooler compartments **16**, **24** are streamlined and a width  $W$  (FIG. 4) of the combined engine and cooler compartments **16**, **24** defined perpendicularly to the vehicle longitudinal axis  $F$  (FIG. 2) decreases from an upstream end **114** to a downstream end **116** of the engine assembly **10**. A height  $H$  (FIG. 5) varies from the upstream end **114** to a downstream end **116** so as to define an aerodynamic profile.

In the embodiment shown, the cooler compartment **24** include peripheral walls **118** having apertures defining the cooler compartment inlet **40**. In the illustrated embodiment, then engine assembly **10** has two heat exchangers **28a** and **28b**: a liquid cooler **28a** and an oil cooler **28b**. Each of the two heat exchangers **28a** and **28b** is connected to a respective fluid circuitry. The fluid circuitry of the oil cooler **28b** is connected to an oil distribution system for cooling the oil of the engine assembly **10**, which may include for example oil in the gear box **60**, the compressor **54**, the turbine **58**, and/or the engine **12**. The liquid cooler **28a** is configured for cooling a liquid coolant of the internal combustion engine **12**. In the illustrated embodiment, the heat exchangers **28a**, **28b** are disposed on top and side walls of the cooler compartment **24**. The heat exchangers **28a**, **28b** cover the apertures defining the cooler compartment inlet **40** such that at least a portion of a wall or an entirety of a wall of the cooler compartment **24** is defined by the heat exchangers **28a**, **28b**. For example, the cooler compartment **24** is defined by the walls **118** extending from and connected around a perimeter of the heat exchangers **28a**, **28b**, with the inlet side of the heat exchangers **28a**, **28b** being directly exposed to the environment **22**, and the opposed outlet side of the heat exchangers **28a**, **28b** being directly exposed to the interior **36** of the cooler compartment **24**. The heat exchangers **28a**, **28b** are thus partly inside the cooler compartment **24** and partly exposed to the environment **22**.

In the depicted embodiment and as can be best shown in FIG. 5, the conduit **76** interconnecting the compressor outlet **74** to the internal combustion engine **12** engine assembly **10** defines an air manifold **120** adjacent the internal combustion engine **12**, for example for distributing the compressor air to the rotor units. Other configurations are also possible.

In the embodiment shown, the forced air system **46** includes a fan, or blower, **130** disposed adjacent the cooler compartment outlet **38**. As can be best seen in FIG. 5, the fan **130** is disposed within an outlet duct **132**. In the depicted embodiment, the fan **130** is driven by an electrical motor or a hydraulic motor. Other suitable motors may be used. In a particular embodiment, the fan **130** is driven by a hydraulic or a pneumatic transmission. Alternately, the fan **130** may be driven by the internal combustion engine **12** and/or the turbine section **58**. It is understood that any other suitable

type of forced air system, including, but not limited to ejector(s), pump(s), etc., may alternately be used.

In the illustrated embodiment, the outlet duct 132 is fluidly connected with the cooler compartment interior 36 via the outlet 38 of the cooler compartment 24. The outlet duct 132 is affixed to one of the peripheral walls 118 of the cooler compartment 24. In the embodiment shown, the outlet duct 132 is affixed to a rear wall 134 (or rear firewall) of the cooler compartment 24 and extends away from the cooler compartment 24. The outlet duct 132 fluidly connects the interior 36 of the cooler compartment 24 to the environment 22 via the cooler compartment outlet 38.

It can be seen that the engine and cooler compartments 16 and 24 are serially disposed in a direction of the longitudinal axis L of the outlet duct 132. In the illustrated embodiment, the exhaust duct 94 extends through an aperture 136 in the rear wall 134 of the cooler compartment 24 before being connected with the exhaust plenum 104.

Still referring to FIG. 5, in the embodiment shown the exhaust plenum 104 is annular and disposed around the duct 132. The exhaust plenum 104 has a circumferential outer wall 140 surrounding the outlet duct 132, an annular fore wall 142 and an annular aft wall 144. The annular fore and aft walls 142 and 144 are offset from one another along a longitudinal axis L of the outlet duct 132 and extend radially outwardly from the outlet duct 132. An inlet 146 of the exhaust plenum 104 is defined through the circumferential outer wall 140, and is connected to the exhaust duct 94 so as to receive the exhaust gases from the turbine section 58. An outlet of the exhaust plenum 104 is defined through the wall portion 148 (FIG. 3) of the outlet duct 132 which extends within the exhaust plenum 104, between the walls 142, 144. Therefore, the exhaust plenum 104 is configured to output the flow of exhaust gases in a radially inward direction relative to the longitudinal axis L of the outlet duct 132. The exhaust plenum 104 radially discharges the flow of combustion gases in the outlet duct 132 at a location downstream from the fan 130, so as to avoid exposing the fan 130 to the exhaust gases. The exhaust gases from the engine 12 are thus mixed with the airflow F' (FIG. 1) of the fan 130 within the duct 132 downstream of the fan 130 before being expelled in the environment 22.

In the embodiment shown, an aft portion 150 (FIG. 5) of the outlet duct 132 extends downstream of the annular aft wall 144. The flow of exhaust gases and the flow generated by the forced air system 46 are expelled in the environment 22 through the aft portion 150.

In the depicted embodiment, the longitudinal axis L of the outlet duct 132 is substantially parallel to the longitudinal axis F of the helicopter 112 (FIG. 2). Hence, the airflow of the forced air system 46 and the exhaust gases create a thrust that may overcome a portion of the drag of the vehicle 112. Moreover, a temperature of the gas expelled in the environment is reduced by mixing the exhaust gases from the internal combustion engine 12 with the airflow F' generated by the forced air system 46. In a particular embodiment, the temperature of the flow exiting the aft portion 150 of the outlet duct 132 is about 350° F. Other values are also possible.

Referring back to FIG. 2, each of the engine assemblies 10 of the helicopter 112 has an outlet 200, defined by the respective aft portion 150 of the outlet duct 132 (FIG. 5). In the illustrated embodiment, the outlets 200 are side-by-side, i.e. spaced apart along a direction perpendicular to the longitudinal axis F of the helicopter. The exit flow axes L' and L'' of the engine assemblies 10 are parallel to one

another, and parallel or substantially parallel to the longitudinal axis F of the helicopter 112.

Referring to FIGS. 1-5, in use and in a particular embodiment, in order to cool the internal combustion engine 12 received in the engine compartment 16 that is separated from the cooler compartment 24 by the common wall 42, air is expelled from the cooler compartment 24 toward the environment 22 with the forced air system 46 to simultaneously create the main and secondary airflows 50 and 52. In the illustrated embodiment, the main airflow 50 is created by drawing outside air in the cooler compartment 24 from the environment 22 of the cooler compartment 24. In so doing, the outside air is heated before it is received in the cooler compartment 24 by cooling a fluid of the internal combustion engine 12 or of the engine assembly 10. For example, the fluid may be oil of the internal combustion engine 12 and/or of the engine assembly 10 as a whole, and/or a liquid coolant for the internal combustion engine 12. The secondary air flow 52 is created by drawing air in the cooler compartment 24 from the engine compartment 16 through the metered opening 44 in the common wall 42.

In the illustrated embodiment, the metered opening 44 is the gap 98 between the peripheral surface of the aperture 96 of the common wall 42 and the exhaust duct 94 that passes through the aperture 96. The engine compartment is cooled by passing air from the engine compartment 16 to the cooler compartment 24 through the gap 44 around the exhaust duct 94.

In a particular embodiment, expelling air from the cooler compartment includes mixing the expelled air with the exhaust from the internal combustion engine 12, and/or generating thrust with the expelled air.

The above description is meant to be exemplary only, and one skilled in the art will recognize that changes may be made to the embodiments described without departing from the scope of the invention disclosed. Modifications which fall within the scope of the present invention will be apparent to those skilled in the art, in light of a review of this disclosure, and such modifications are intended to fall within the appended claims.

The invention claimed is:

1. An engine assembly for a helicopter having a longitudinal axis extending from a front end to a rear end of the helicopter, comprising:

a) an engine compartment containing an internal combustion engine, the internal combustion engine having internal cooling circuitry for fluid cooling of the engine, the engine compartment having an air intake fluidly connecting an interior of the engine compartment to an environment of the engine assembly;

a) a cooler compartment separate from the engine compartment by a wall extending substantially transversally to the longitudinal axis, the cooler compartment and the engine compartment being serially disposed in a direction of the longitudinal axis and located on opposite sides of the wall, the cooler compartment containing a heat exchanger fluidly connected to the cooling circuitry of the internal combustion engine, an interior of the cooler compartment fluidly connected to the environment via an inlet and an outlet;

a) a metered opening fluidly connecting the engine compartment to the cooler compartment through the wall; and  
a) a forced air system fluidly between the inlet and the outlet and operable to drive an airflow from the inlet to the outlet through the heat exchanger, and from the intake to the outlet through the metered opening.

2. The engine assembly as defined in claim 1, wherein the inlet of the cooler compartment is defined by the heat exchanger.

3. The engine assembly as defined in claim 1, further comprising an exhaust duct fluidly connecting an exhaust of the internal combustion engine to the environment, the exhaust duct passing through an aperture in the wall, the metered opening corresponding to a gap created by a difference between a diameter of the aperture and an outer diameter of the exhaust duct.

4. The engine assembly as defined in claim 3, further comprising at least one turbine in fluid communication with an exhaust of the internal combustion engine, the at least one turbine compounded with the internal combustion engine, the exhaust duct fluidly connected to an outlet of the at least one turbine.

5. The engine assembly as defined in claim 1, further comprising a plenum fluidly connecting an air inlet of the internal combustion engine to the environment, the air intake of the engine compartment being defined by an aperture through a wall of the plenum.

6. The engine assembly as defined in claim 5, further comprising a compressor having an inlet fluidly connected to the plenum, the compressor having an outlet fluidly connected to the air inlet of the internal combustion engine.

7. The engine assembly as defined in claim 1, wherein the forced air system includes a fan located adjacent the outlet.

8. The engine assembly as defined in claim 7, further comprising an exhaust plenum fluidly connected to an exhaust of the internal combustion engine, the forced air system including an outlet duct connected to the outlet of the cooler compartment and containing the fan, the exhaust plenum being annular and disposed around the outlet duct, the exhaust plenum and the outlet duct being in fluid communication along a radial direction relative to a longitudinal axis of the outlet duct at a location downstream of the fan for mixing a flow of exhaust gases of the internal combustion engine with the airflow of the forced air system.

9. The engine assembly as defined in claim 1, wherein the engine compartment and the cooler compartment are serially disposed in a direction parallel to a shaft of the internal combustion engine.

10. The engine assembly as defined in claim 1, comprising two of said engine compartment and two of said cooler compartment, each engine compartment communicating with a respective one of the cooler compartments.

11. An engine assembly for a helicopter having a longitudinal axis extending from a front end to a rear end of the helicopter, comprising:

a compartment having separate engine and cooler sections fluidly connected with each other through an opening defined through a wall extending substantially transversally to the longitudinal axis, the engine and cooler sections serially disposed in a direction of the longitudinal axis and located on opposite sides of the wall, the engine section having an air intake fluidly connecting an interior of the engine section to an environment of the engine assembly, an interior of the cooler section fluidly connected to the environment of the engine assembly via an inlet and an outlet;

a compound engine received in the engine section and including a compressor in fluid communication with the environment of the engine assembly, an internal combustion engine having an inlet in fluid communication with an outlet of the compressor, and a turbine having an inlet in fluid communication with an exhaust of the internal combustion engine, the turbine com-

pounded with the internal combustion engine, the compressor in driving engagement with at least one of the turbine and the internal combustion engine;

a heat exchanger received in the cooler section, the heat exchanger fluidly connected to a fluid circuitry of the compound engine, the interior of the cooler section fluidly connected to the inlet of the cooler section via the heat exchanger; and

a forced air system operable to drive an airflow, the forced air system in simultaneous fluid communication with a main flow path and a secondary flow path, the main flow path extending from the inlet of the cooler section to the outlet of the cooler section via the heat exchanger and the interior of the cooler section, the secondary flow path extending from the air intake of the engine section to the outlet of the cooler section via the interior of the engine section, the opening and the interior of the cooler section.

12. The engine assembly as defined in claim 11, further comprising an exhaust duct fluidly connecting an outlet of the turbine to the environment, the exhaust duct passing through an aperture in the wall, the opening corresponding to a gap created by a difference between a diameter of the aperture and a diameter of the exhaust duct.

13. The engine assembly as defined in claim 11, wherein the forced air system includes a fan located adjacent the outlet.

14. The engine assembly as defined in claim 13, further comprising an exhaust plenum fluidly connected to an outlet of the turbine, the forced air system including an outlet duct connected to the outlet of the cooler section and containing the fan, the exhaust plenum being annular and disposed around the outlet duct, the exhaust plenum and the outlet duct being in fluid communication along a radial direction relative to a longitudinal axis of the outlet duct at a location downstream of the fan for mixing a flow of exhaust gases of the internal combustion engine with the airflow of the forced air system.

15. The engine assembly as defined in claim 11, further comprising a plenum fluidly connecting an air inlet of the compressor to the environment, the air intake of the engine section being defined by an aperture through the plenum.

16. The engine assembly as defined in claim 11, wherein the engine compartment and the cooler compartment are serially disposed in a direction parallel to a shaft of the internal combustion engine.

17. The engine assembly as defined in claim 11, wherein the internal combustion engine is a rotary engine.

18. A method for cooling an internal combustion engine received in an engine compartment of a helicopter separated from a cooler compartment of the helicopter, the helicopter having a longitudinal axis extending from a front end to a rear end of the helicopter, the method comprising:

expelling air from the cooler compartment to an environment with a forced air system to simultaneously create main and secondary airflows, wherein:

creating the main airflow includes drawing outside air in the cooler compartment from the environment separately from the engine compartment; and

creating the secondary airflow includes drawing additional air in the cooler compartment from the engine compartment through an opening fluidly connecting the cooler and engine compartments, the opening defined through a wall extending substantially transversally to the longitudinal axis, the cooler compartment and the engine compartment being serially

disposed in a direction of the longitudinal axis and located on opposite sides of the wall.

19. The method as defined in claim 18, wherein creating the main airflow further comprises heating the outside air circulated into the cooler compartment by cooling a fluid of the internal combustion engine. 5

20. The method as defined in claim 18, wherein the opening is a gap between a peripheral surface of an aperture of the wall separating the cooler and engine compartments and an exhaust duct of the internal combustion engine passing through the aperture, the method further comprising circulating air passing from the engine compartment through the gap around the exhaust duct. 10

21. The method as defined in claim 18, wherein expelling the air from the cooler compartment includes mixing the expelled air with exhaust from the internal combustion engine. 15

22. The method as defined in claim 18, wherein expelling the air from the cooler compartment includes generating thrust with the expelled air. 20

\* \* \* \* \*